NAVY DEPARTMENT - BUREAU OF AERONAUTICS

NS-11
(42944)E6-1

NAVY DEPARTMENT * BUREAU OF AERONAUTICS

U.S. Bureau of Aeronautics (Navy Dept.)

17 JUN 1943

To: BuAer

Subj: Project No. 4416 - Positive Pressure Breathing Equipment - Interim Report of Development to date

1. Repeated ascents to simulated altitudes in the low pressure chamber with the use of the Pioneer demand pressure oxygen regulator have been made and over a period of time the following observations have been made:

(a) That with pressurized breathing equipment a gain in altitude may be obtained over the altitude afforded by conventional oxygen equipment. The enclosed charts of oximeter readings show that the percentage of arterial oxygen saturation is definitely increased by pressure breathing. The graphs show the calculated percentage oxygen saturation with the usual methods of giving oxygen as a black printed line for comparison. Further tests by comparing oximeter readings show that the gain in oxygen saturation is equal to the amount of pressure used or that the altitude over usual O_2 equipment may be calculated by adding the inches of water pressure used to the absolute pressure expressed in inches of water of the ambient altitude.

(b) The problems of aeroembolism are not favorably affected by pressure breathing as many manifestations of this condition have occurred. In many instances at altitudes over 46,000 feet it was noted that the symptoms of aeroembolism, either pain in the joints or "chokes", developed much more rapidly and severely than usual. X-ray photographs are enclosed showing gas bubbles in the tendon sheaths of the fingers and in the wrist joints and further studies are to be made of bubbles in the spinal fluid and brain.

(c) At sea level the using of 8 inches water positive pressure is uncomfortable and somewhat tiring if used for a period of time. However, as altitude is increased, these conditions become progressively decreased until at 42,000 feet and higher the breathing effort is practically the same as that required when the conventional oxygen equipment is used.

(d) The question of personnel being able to breathe against the positive pressure, if unconscious, has been of importance, as expiration with this type of equipment requires effort which is not the normal process. At an altitude of 35,000 feet unconsciousness was produced by allowing ambient air only to be breathed and upon loss of consciousness, the mask tube was inserted back into the regulator and breathing continued with consciousness being regained shortly.

(e) Electrocardiograms have been made at simulated altitudes of 30,000, 40,000, 46,000 and 48,000 feet while using 8 and 10 inches water positive pres-

sure and no sign of interference with the normal heart tracings have been found. Fluoroscopic observations of the heart while using various pressures from 4 to 16 inches H_2O at sea level where pressure breathing would be the most productive of changes revealed no demonstrable changes in the heart silhouette.

(f) Due to the exhaling via the mask tubing through the regulator to the outside, the water vapor in the exhaled air is a source of danger at low temperatures. On several occasions freezing in the regulator has caused the exhalation valve to fail to seat properly allowing leakage of air into the regulator which is exceedingly dangerous at critical altitudes where the regulator would be used. To overcome this, a heater for the regulator has been devised and a heater for the mask tubing would also be of aid. Another manner in which this may be overcome would be to have a spring loaded exhalation valve in the mask, thus obviating the exhalation through the regulator.

(g) To date most of the runs with pressure breathing equipment have been made with an M.S.A. Type D oxygen mask modified to the extent that the exhalation valves have been removed and the orifices plugged. A three strap suspension for the mask has been used which would be of no practical use in service. However, an experimental M.S.A. mask made for the Army has been modified by the Naval Aircraft Factory and is very satisfactory from the point of suspension from the service helmet, photograph of which is enclosed. A mask for positive pressure breathing manufactured by the Ohio Chemical Company has been inspected and six have been ordered for developmental use.

(h) Simulated bail outs from an altitude of 46,000 feet at a calculated rate of fall corresponding to an open parachute descent from that altitude while using the small Army M-1 bail out bottle connected to the system by a T have been completed without loss of consciousness.

(i) A suit devised by Dr. Alvin Barach of Columbia University, New York City has been tested which consists of a pair of hollow rubber pants and a hollow rubber vest connected to each other by a detachable flexible tubing. The hollow vest is in turn connected to the oxygen mask. The oxygen supply is connected to the pants at the desired pressure. Thus the entire suit encased in a cloth over garment to prevent overdistension is inflated at the same positive pressure to which the subject is subjected; namely, if a positive pressure of 8 inches H_2O is desired for breathing the suit is similarly inflated to 8 inches H_2O pressure. This arrangement is to aid in return of the blood from the lower extremities upward and to assist the chest movement in exhaling. From the observations in actual use, it is believed that such arrangement not only complicates the equipment required but is unnecessary at high altitudes while breathing with a positive pressure of as high as 12 inches H_2O, at least with the Pioneer positive pressure demand regulator.

(j) From repeated use with this apparatus, it would seem that with a proper mask and means of suspension pressure breathing can be used for high altitude flights below 40,000 feet with a small amount of pressure of perhaps 3 to 4 inches H_2O to minimize the danger of mask leaks. From 40,000 to 46,000 feet, 8 inches H_2O positive pressure should be used.

(k) The group of pilots who would use this equipment should be indoctrinated in the proper use of the equipment and emphasis is directed to the fact that the subjective effects of pressure breathing are not in any degree the same at altitude as they are at sea level.

(l) The Naval Aircraft Factory hopes to have within the next four to six weeks a complete set of pressurized breathing equipment available for actual flight test and submission to the Bureau.

2. Actual tests, and accumulation of data therefrom, continue. A complete report will be issued when the investigation has progressed to a point where data is factual. Intermediate reports will be submitted to the Bureau for information.

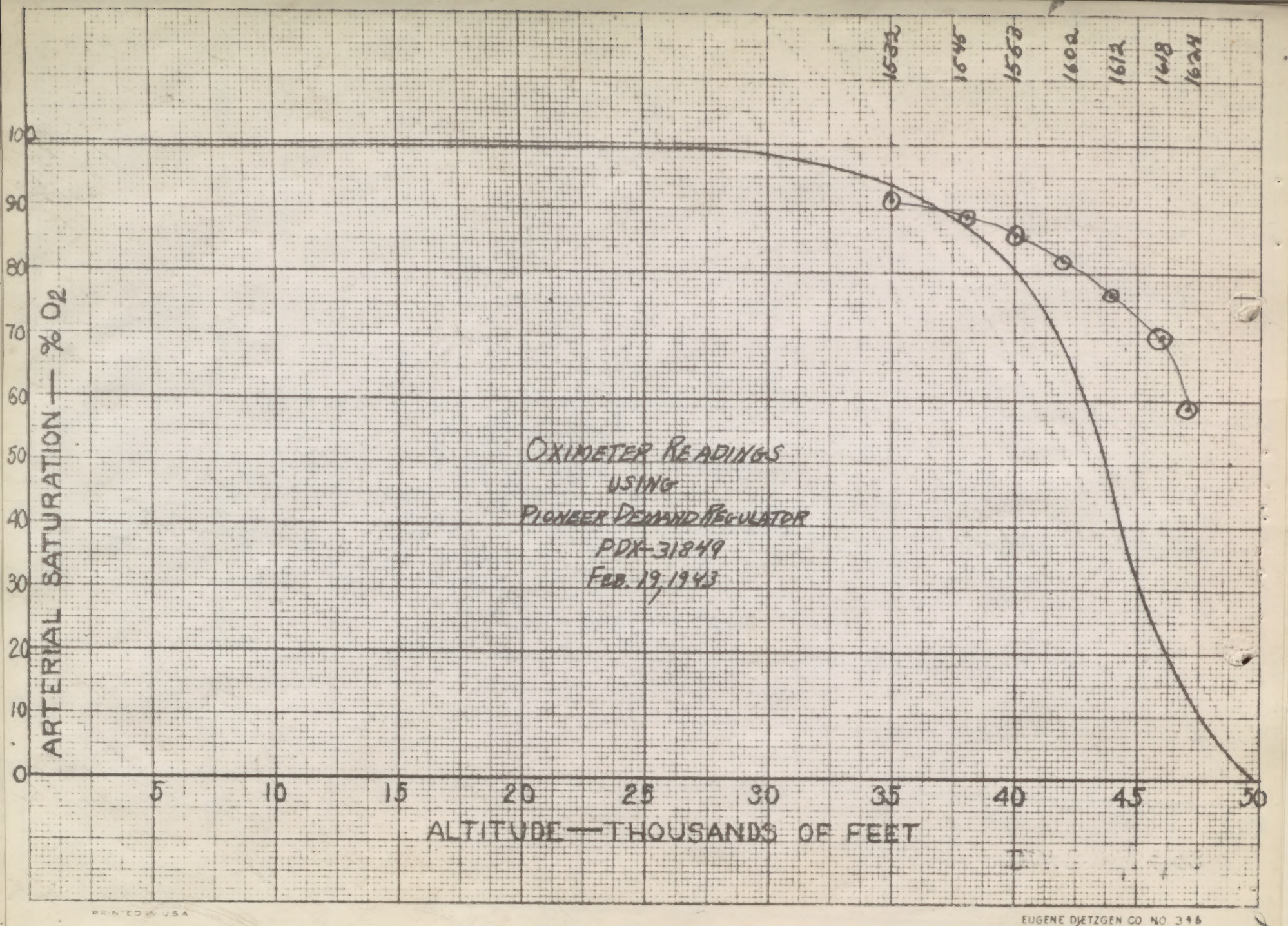
By direction of the Manager.

R. J. H. CONN
Supt., Aero. Matls. Labs.

cc: J. E. Sullivan, Comdr., U.S.N.R.
Bureau of Aeronautics, Wash., D. C.

Encls: (HW)
1 - Oximeter Graphs
2 - Photographs of Gas Bubbles in Tissues.
3 - Photograph of NAF Modification Army M.S.A. Mask

Eq. matl.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ARTERIAL SATURATION — % O2
OXIMETER READINGS
USING
PIONEER DEMAND REGULATOR
PDX-31849
FEB. 19, 1943
5
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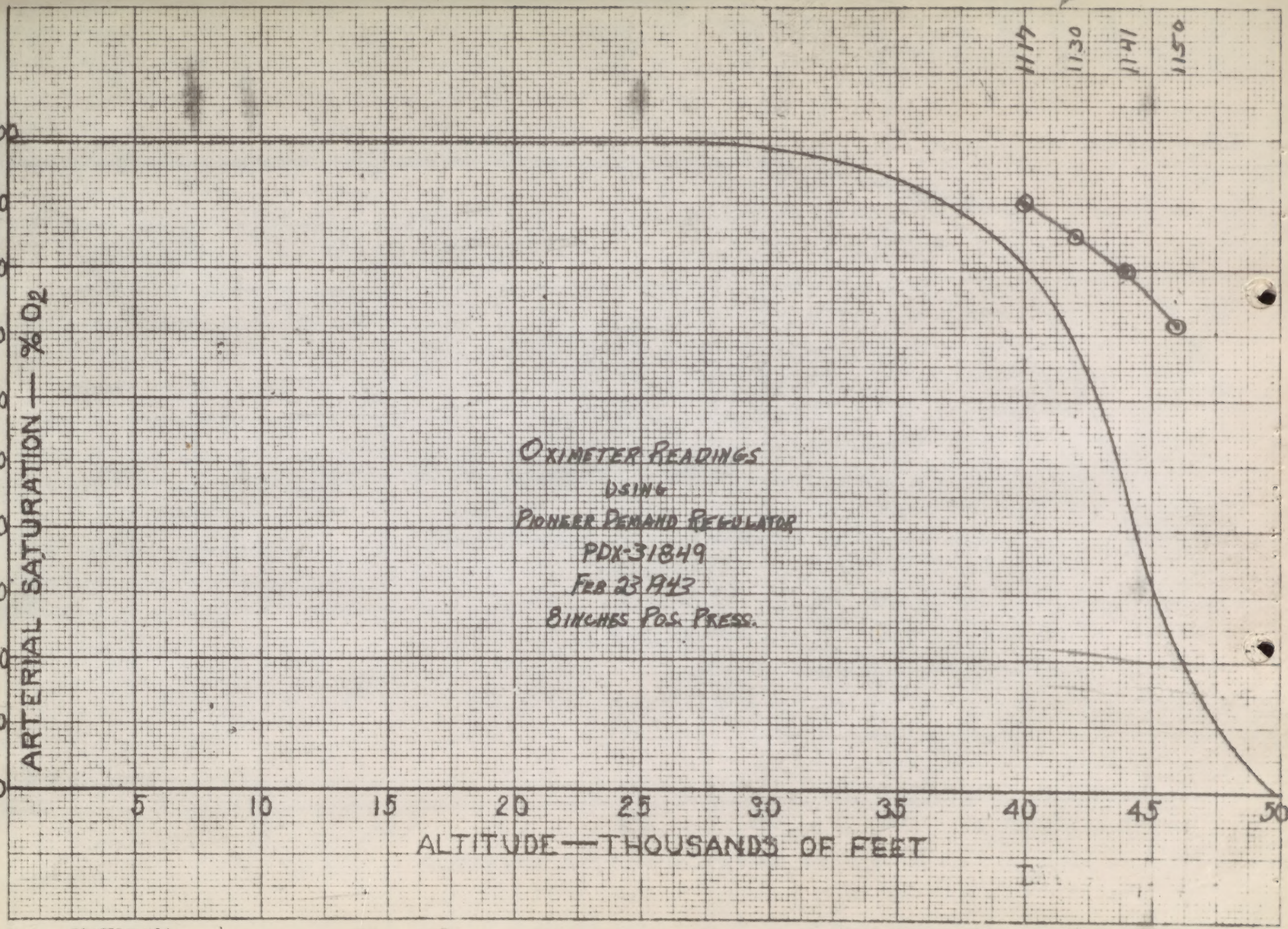
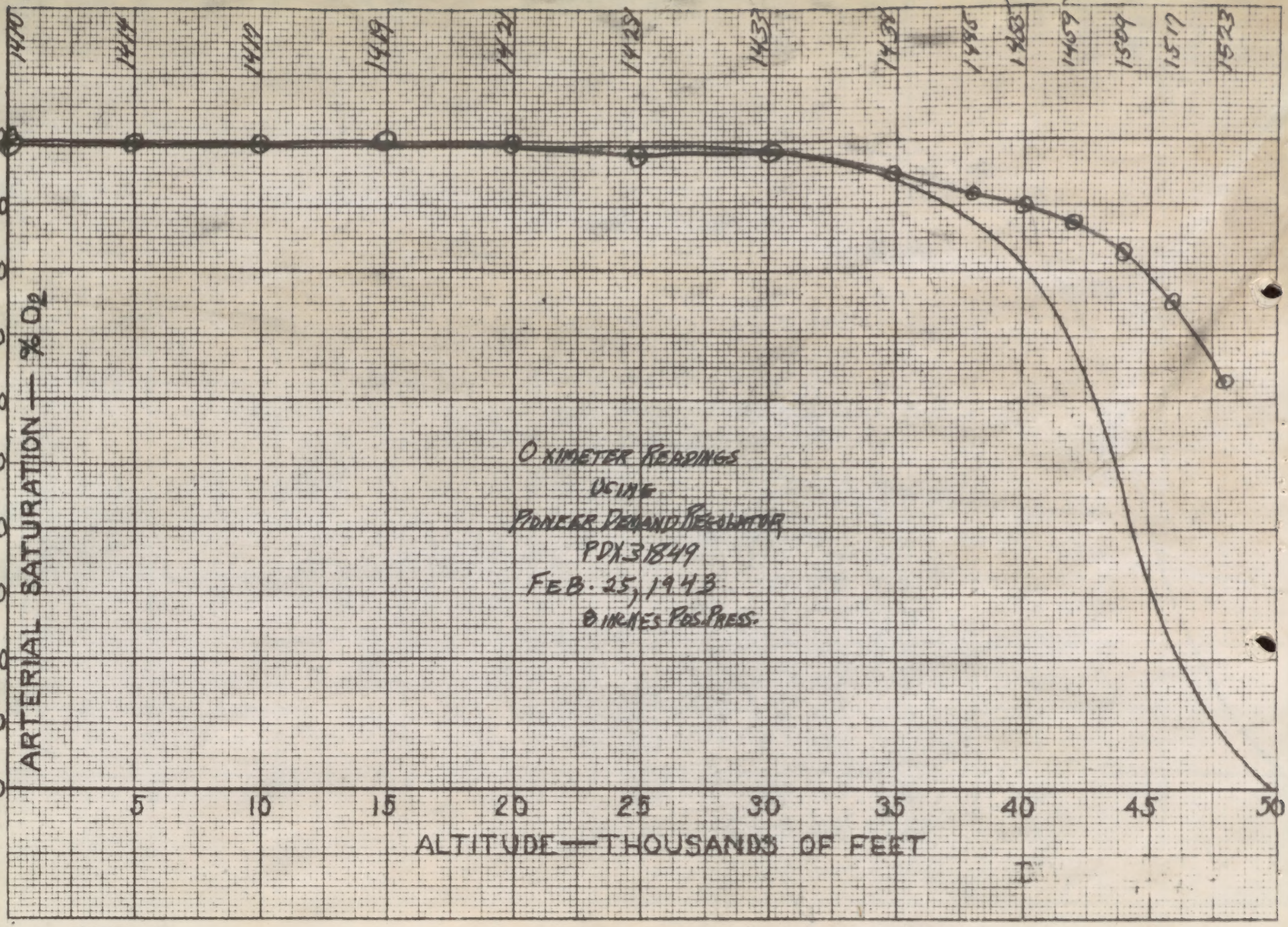
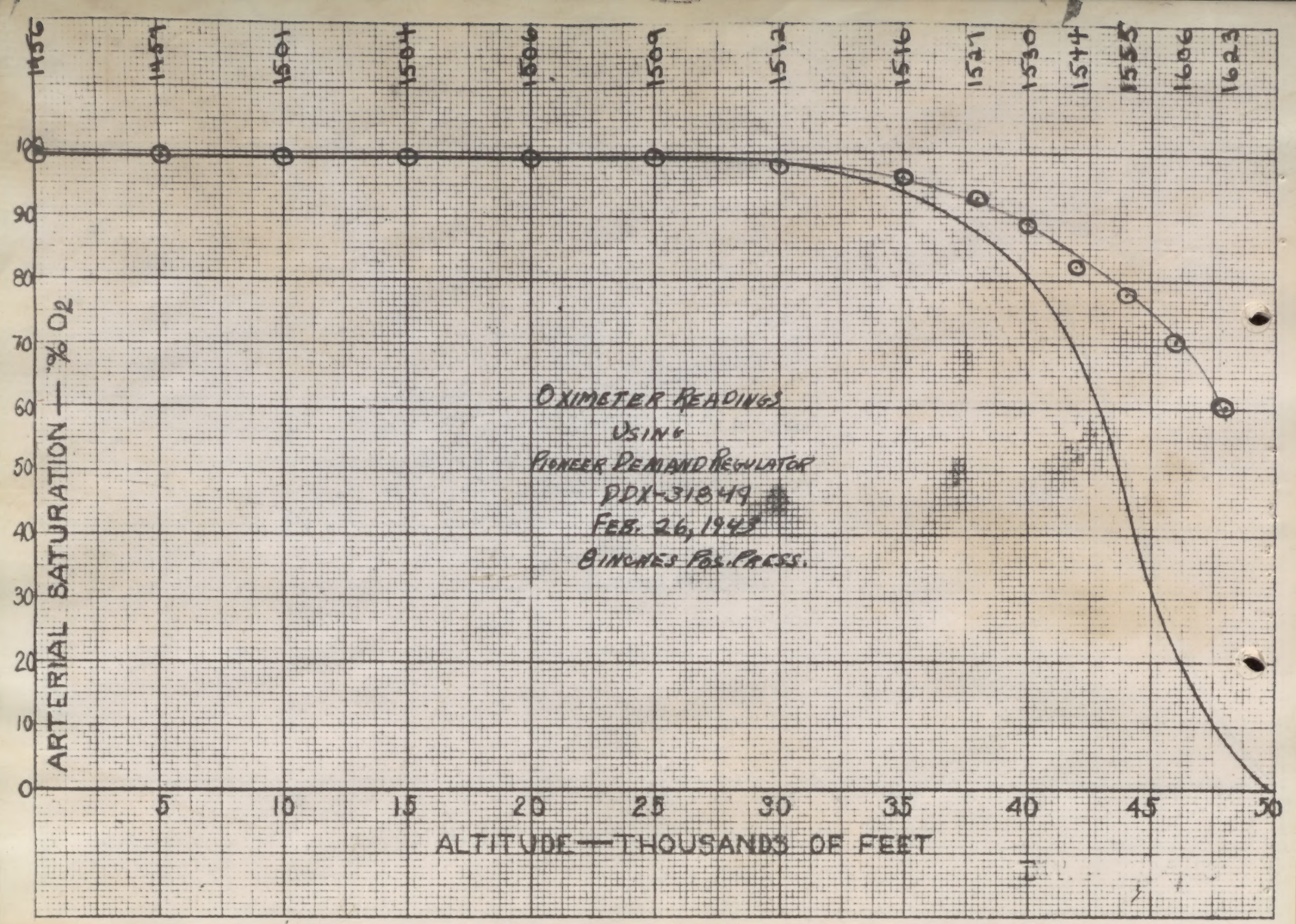
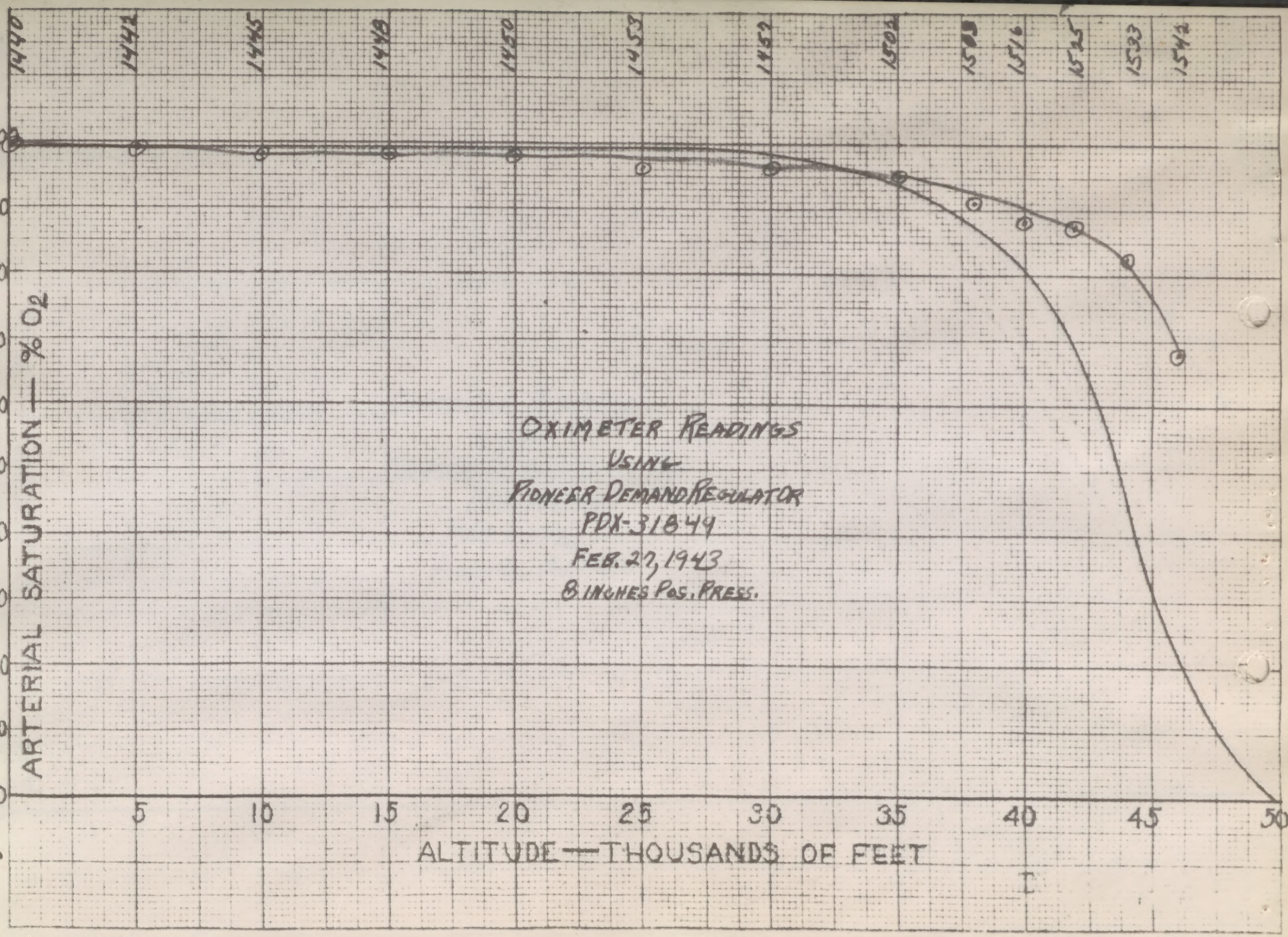
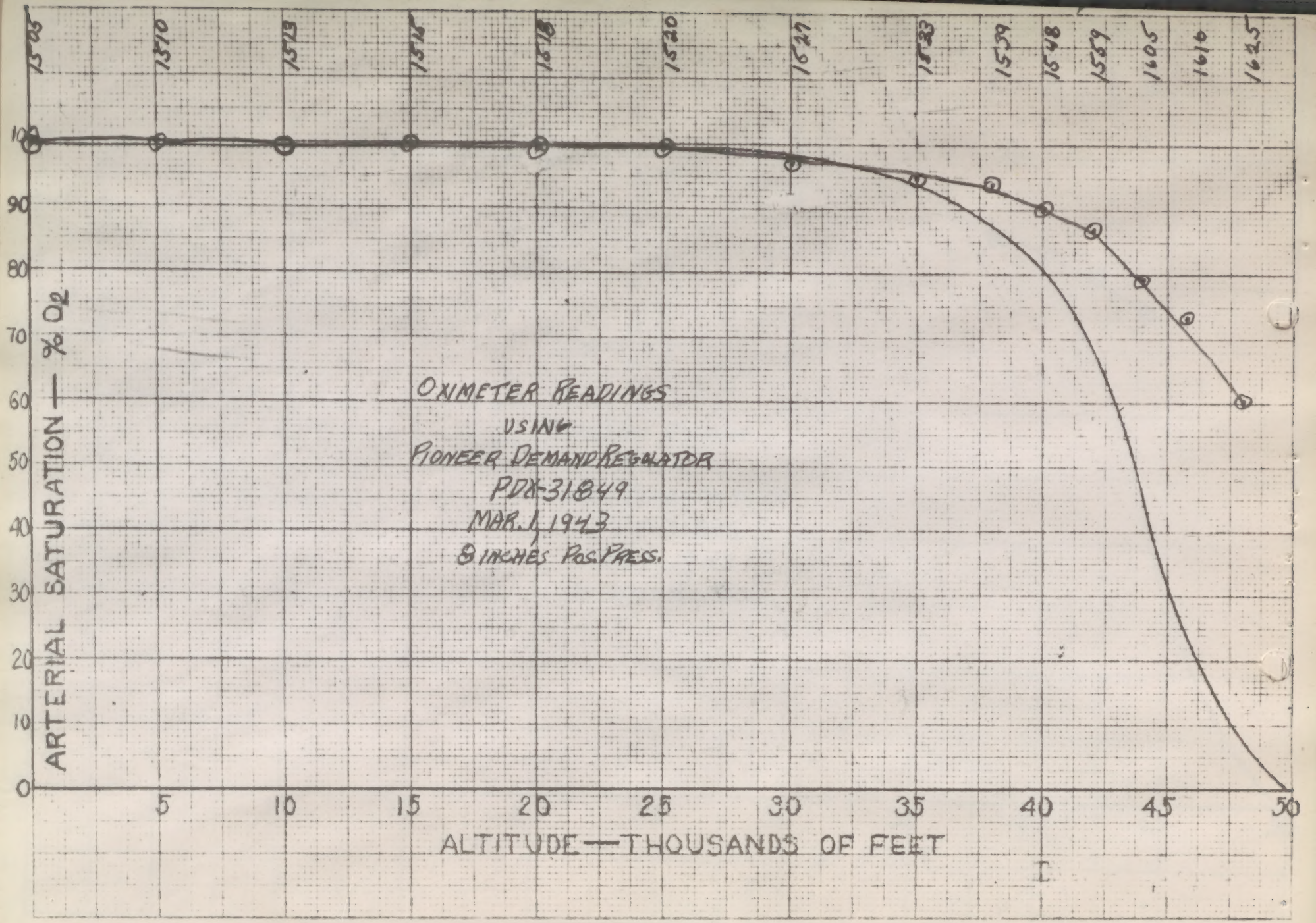
ALTITUDE — THOUSANDS OF FEET
PRINTED IN U.S.A.
EUGENE DIETZGEN CO NO 346











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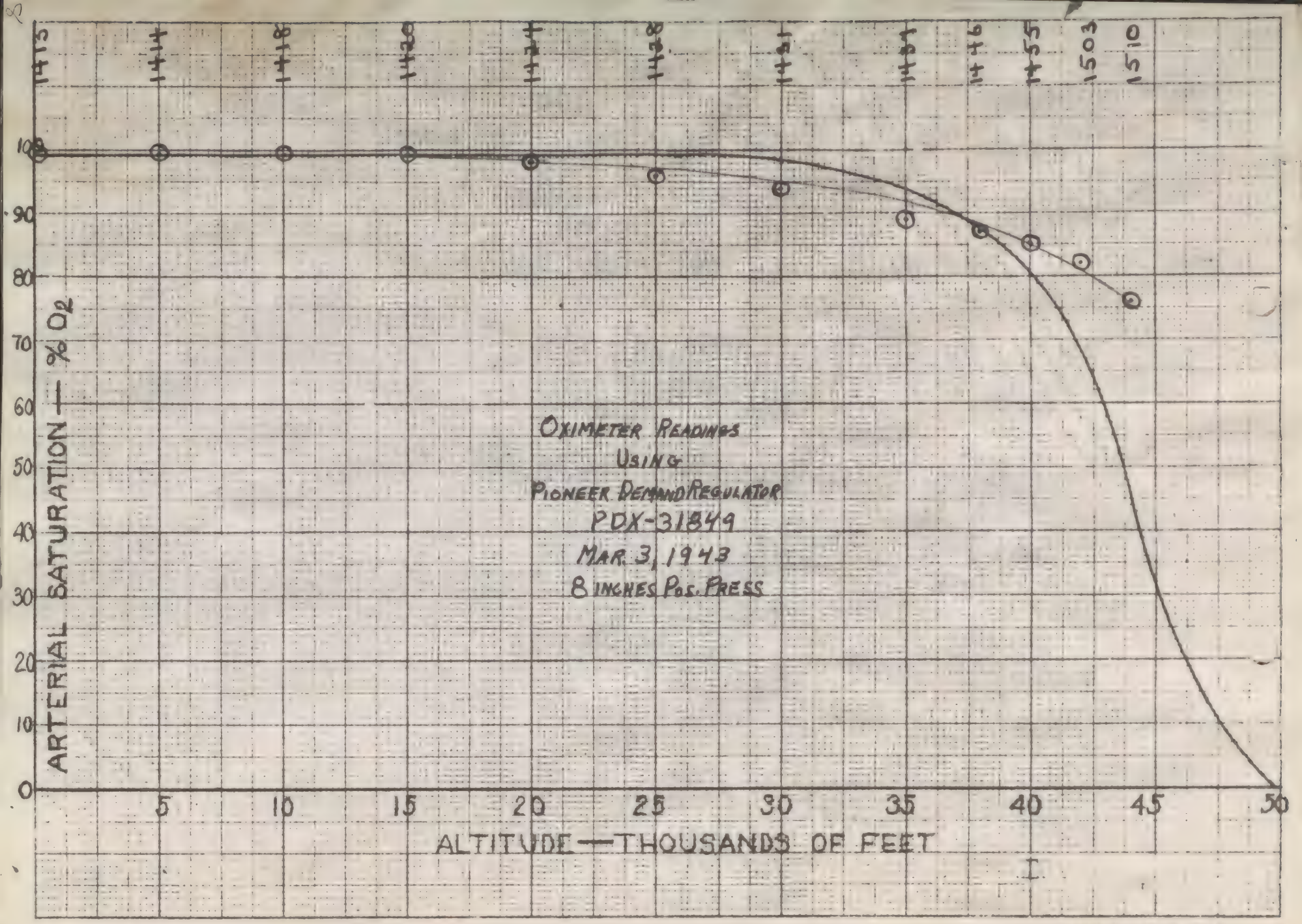

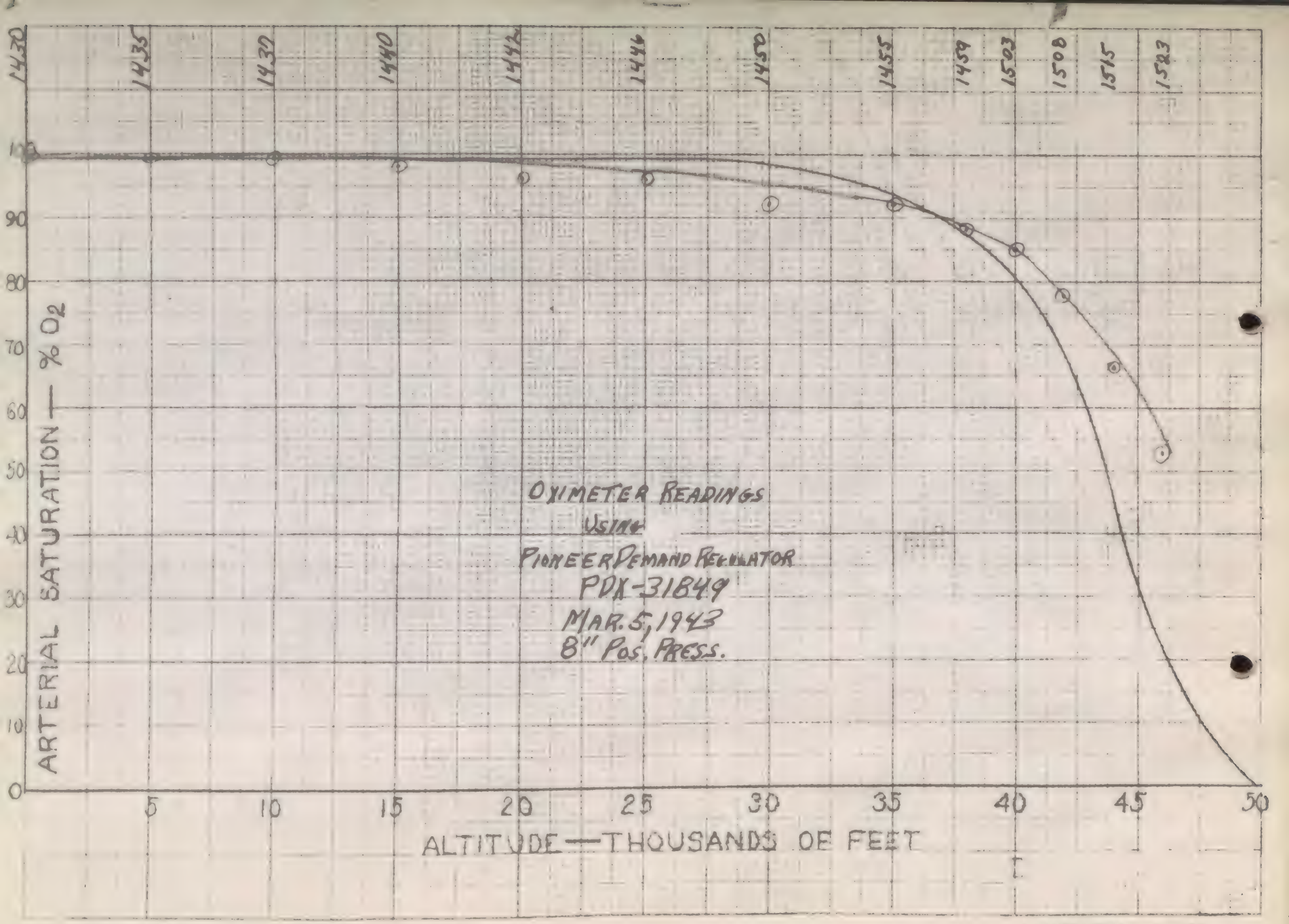
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ARTERIAL SATURATION — % O2
OXIMETER READINGS
USING
PIONEER DEMAND REGULATOR
PDX-31849
MAR. 5, 1943
8" Pos. PRESS.
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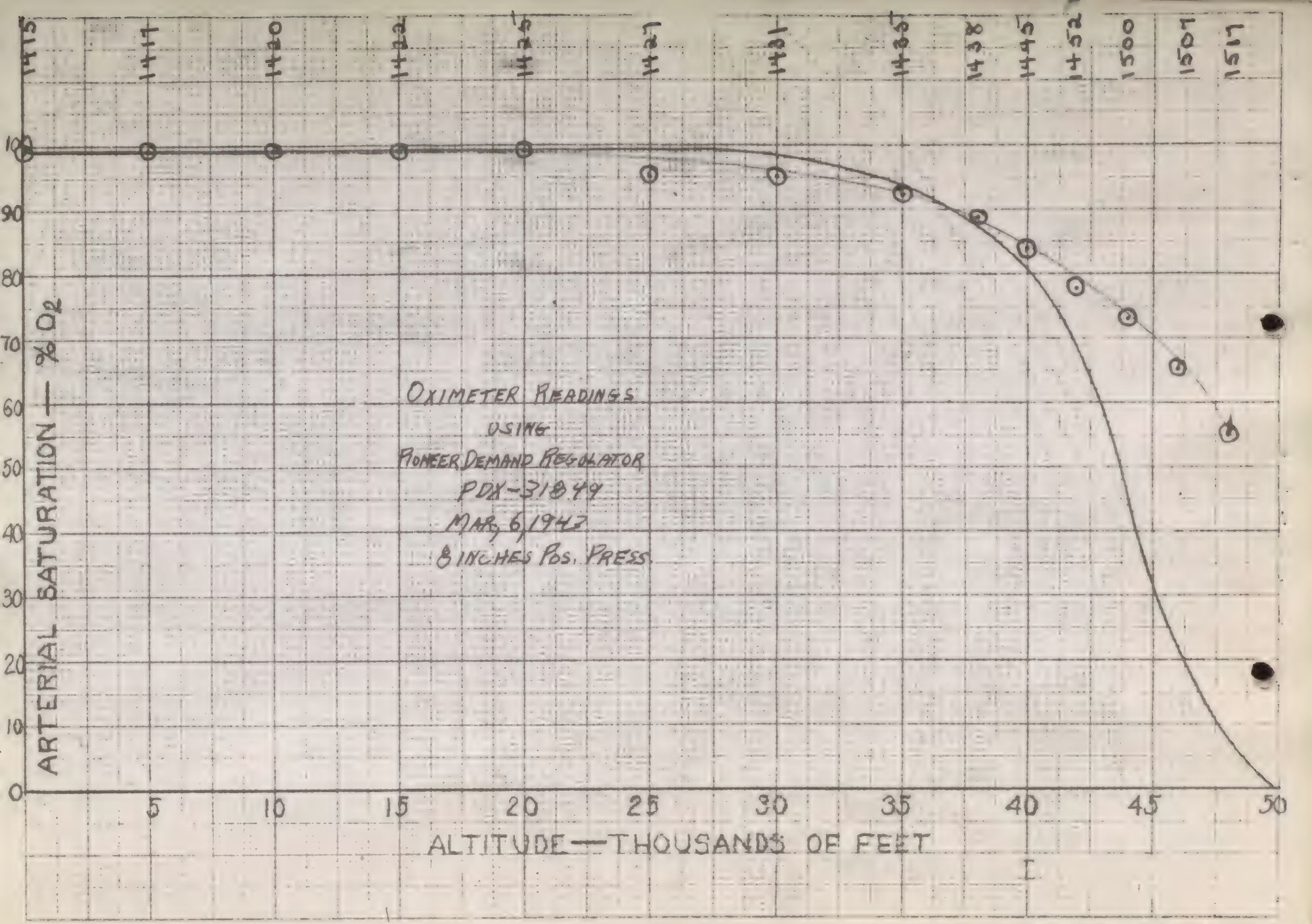
ALTITUDE — THOUSANDS OF FEET


1415
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1452
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ARTERIAL SATURATION — % O2
0
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80
90
100
OXIMETER READINGS
USING
PIONEER DEMAND REGULATOR
PDX-31849
MAR. 6, 1947
8 INCHES POS. PRESS
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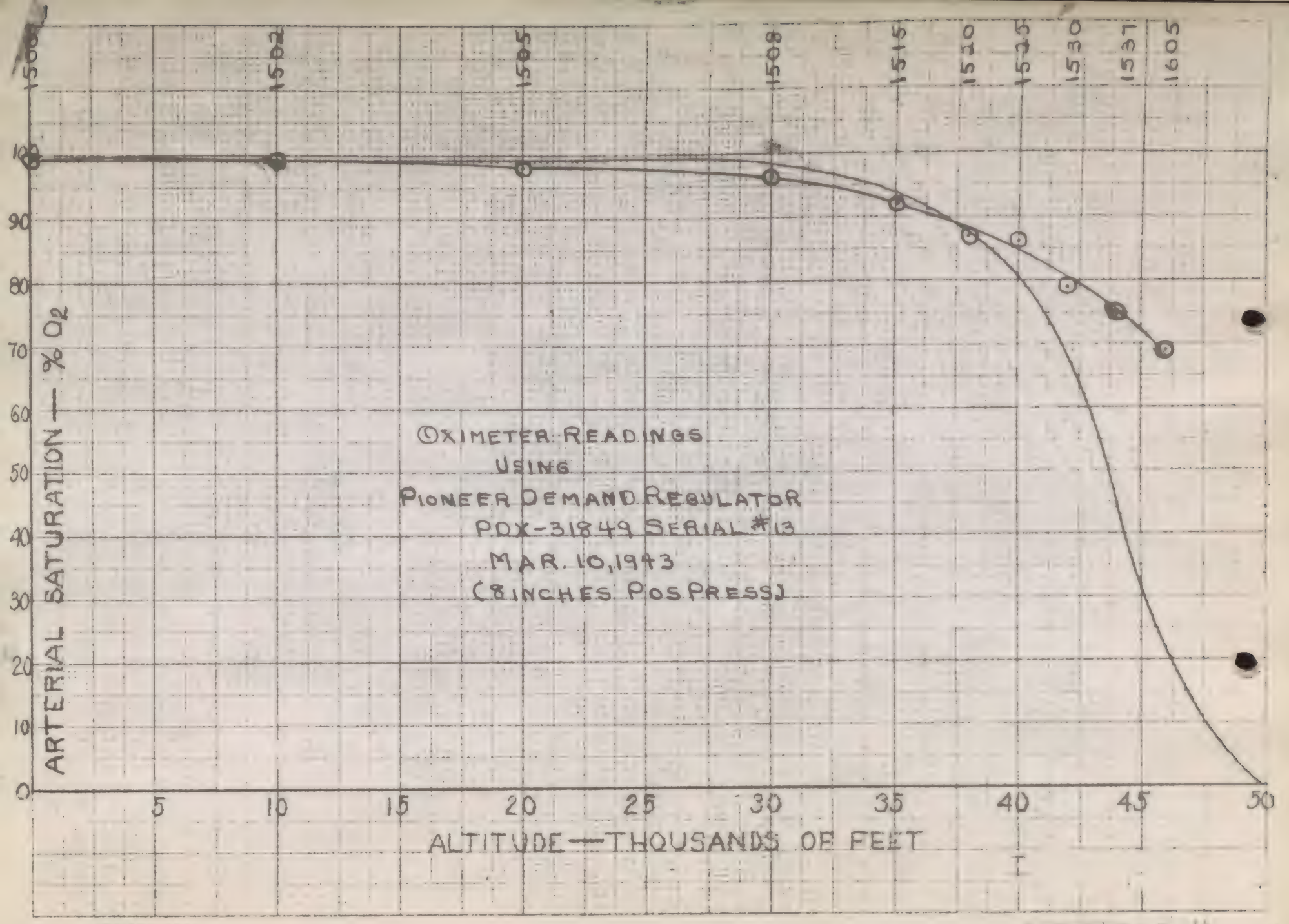
ALTITUDE — THOUSANDS OF FEET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1537
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0
ARTERIAL SATURATION — % O2
OXIMETER READINGS
USING
PIONEER DEMAND REGULATOR
PDX-31849 SERIAL #13
MAR. 10, 1943
(8 INCHES POS PRESS)
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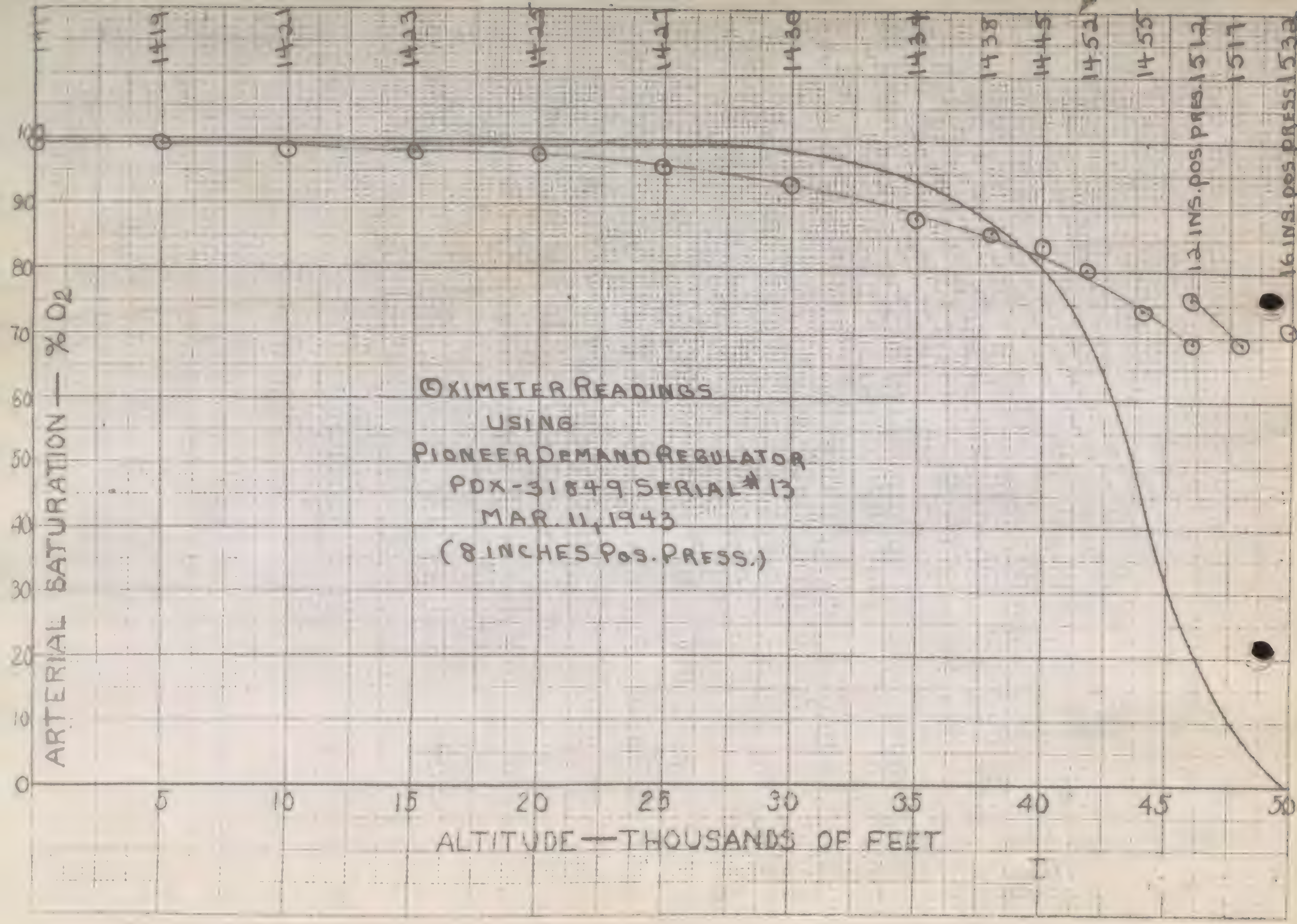
ALTITUDE — THOUSANDS OF FEET


ⓞXIMETER READINGS
USING
PIONEER DEMAND REGULATOR
PDX-31849 SERIAL # 13
MAR. 11, 1943
(8 INCHES POS. PRESS.)
ARTERIAL SATURATION — % O2
ALTITUDE — THOUSANDS OF FEET
0
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40
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80
90
100
5
10
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25
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35
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1419
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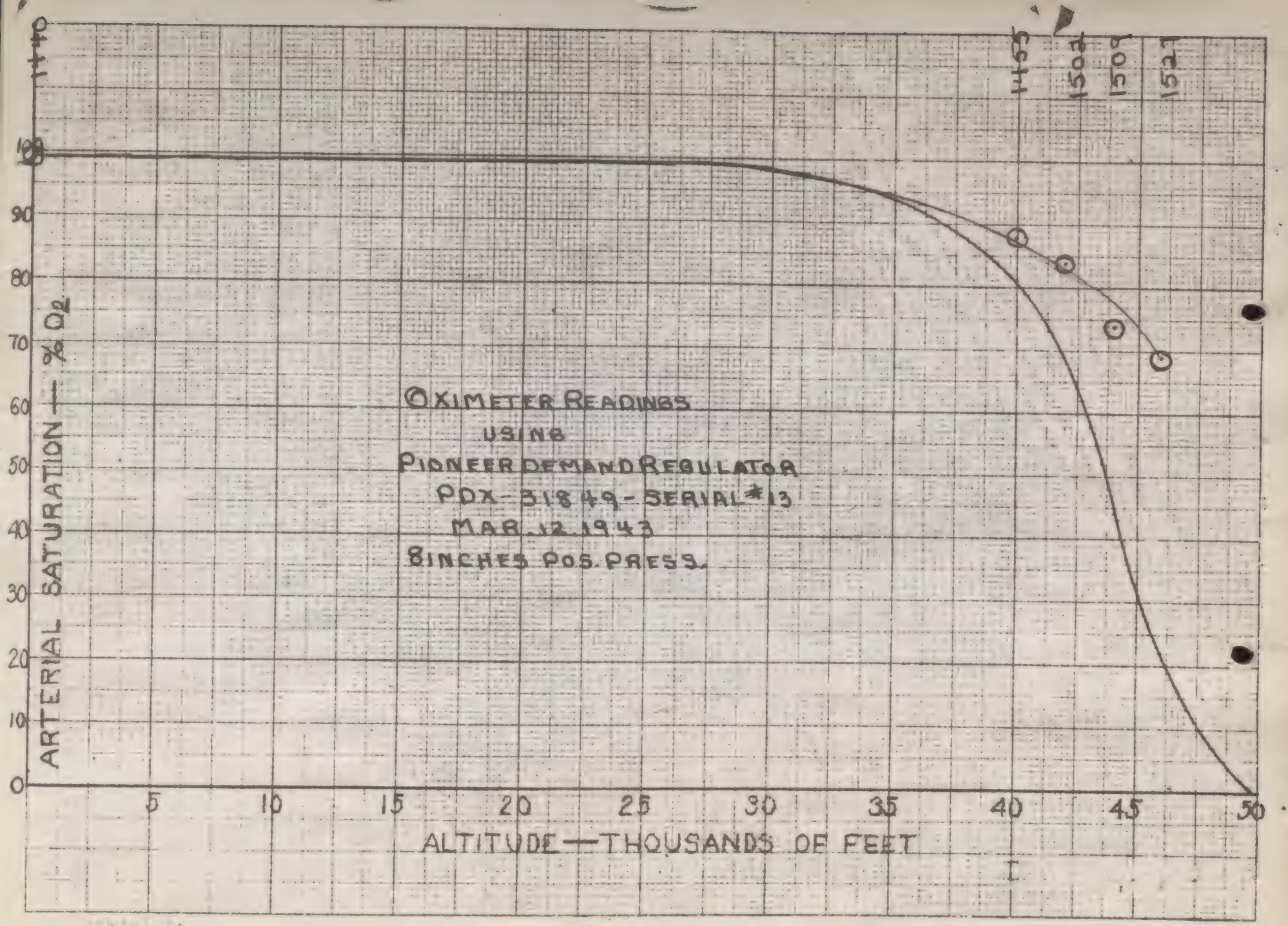
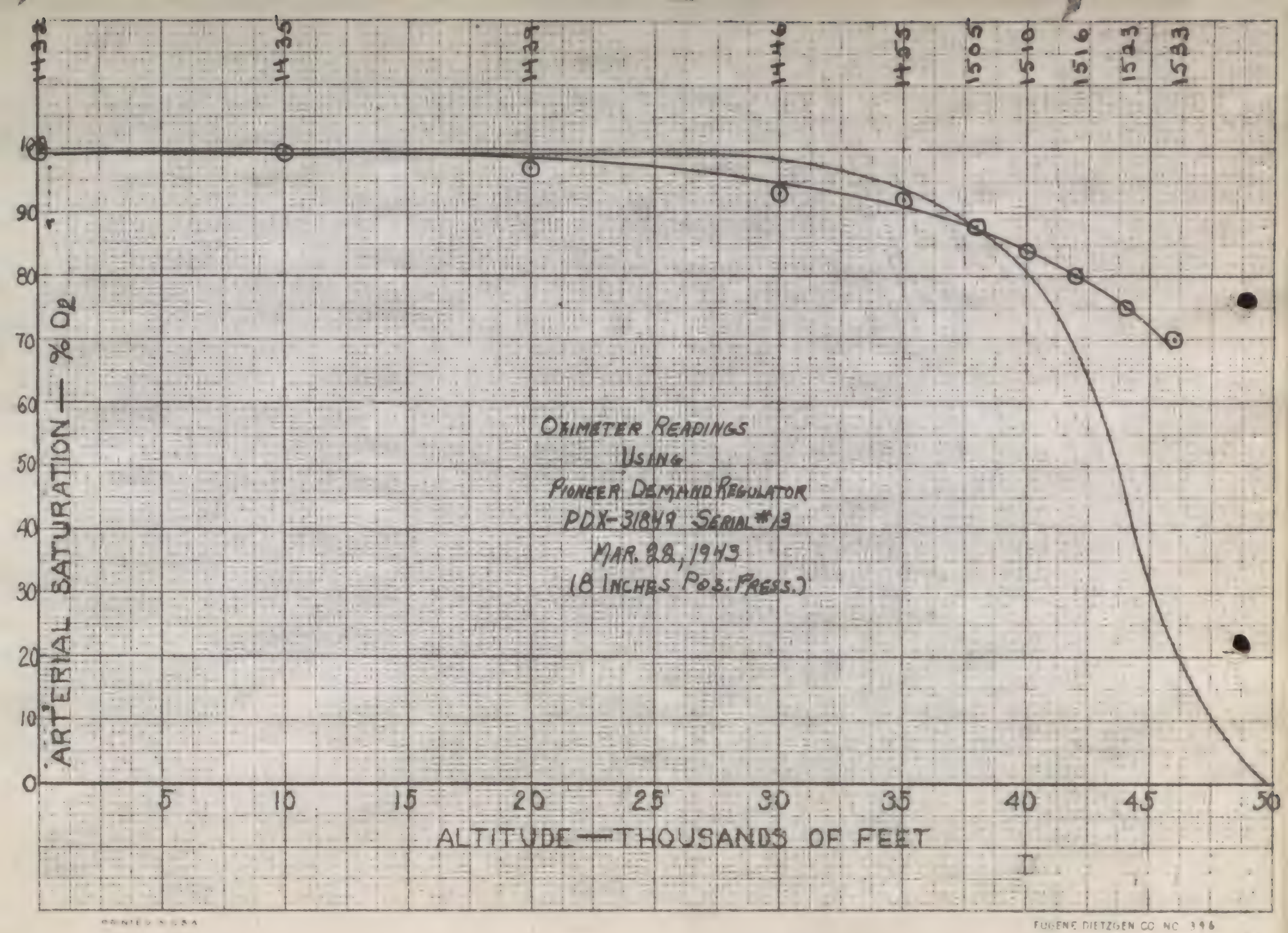
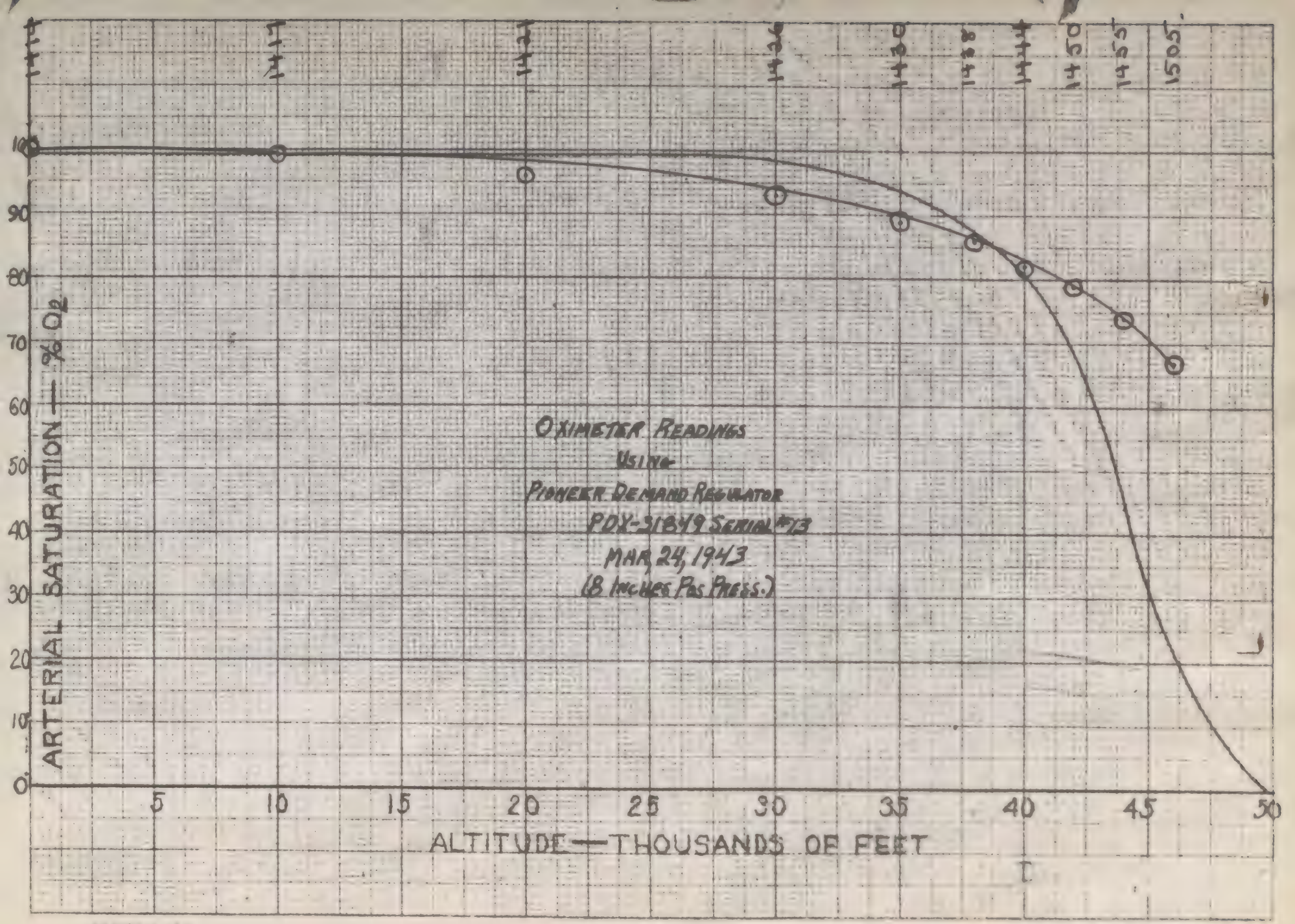
1452
1455
12 INS. pos. PRES. 1512
1517
16 INS. pos. PRESS. 1532



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USING
PIONEER DEMAND REGULATOR
POX-31849 SERIAL #13
MAR. 24, 1943
(8 INCHES POS. PRESS.)
ARTERIAL SATURATION — % O2
ALTITUDE — THOUSANDS OF FEET
0
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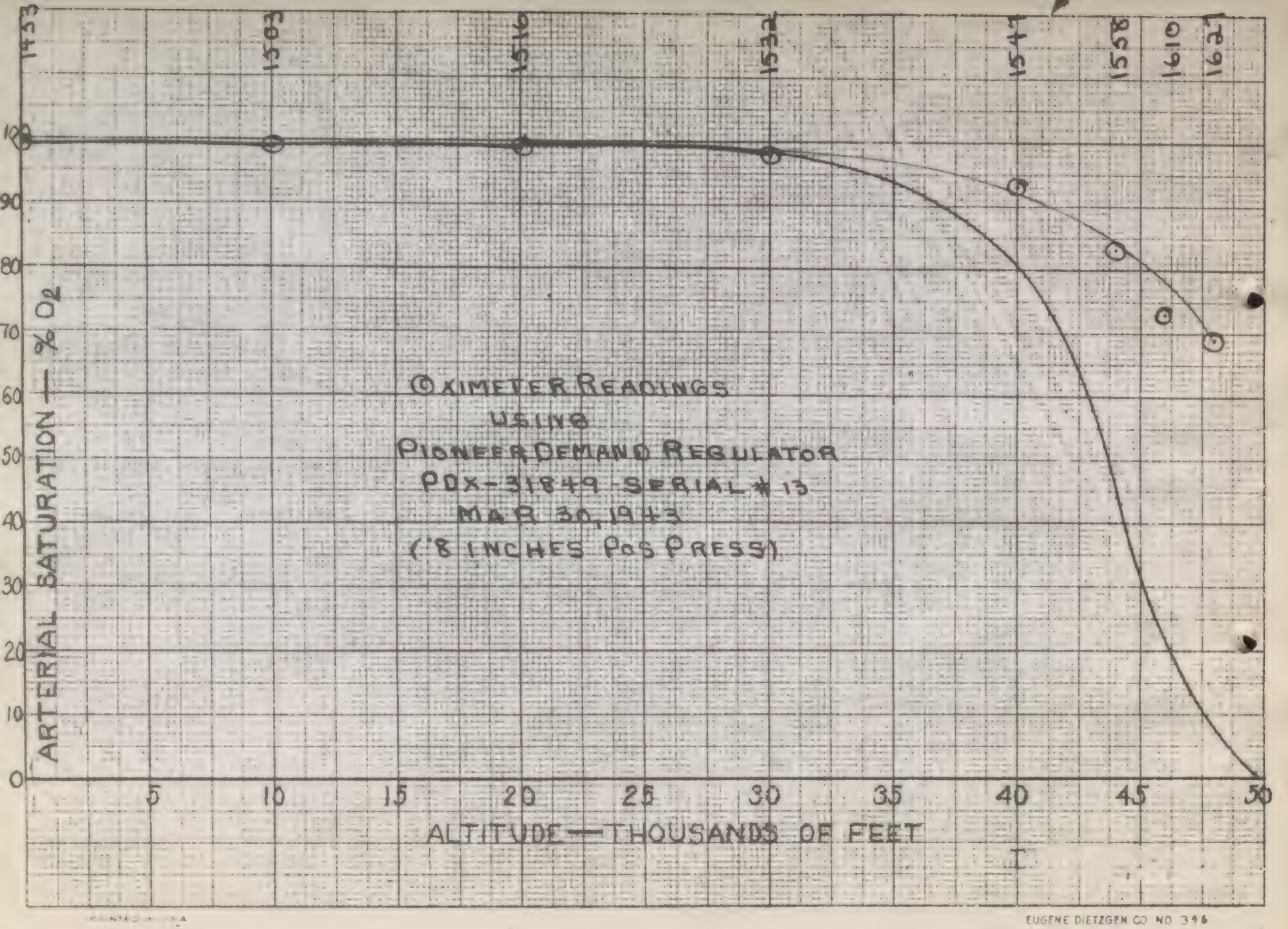
1453
1503
1516
1532
1541
1558
1610
1627
100
90
80
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50
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ARTERIAL SATURATION — % O2
OXIMETER READINGS
USING
PIONEER DEMAND REGULATOR
PDX-31849 SERIAL # 13
MAR 30, 1943
(8 INCHES POS PRESS)
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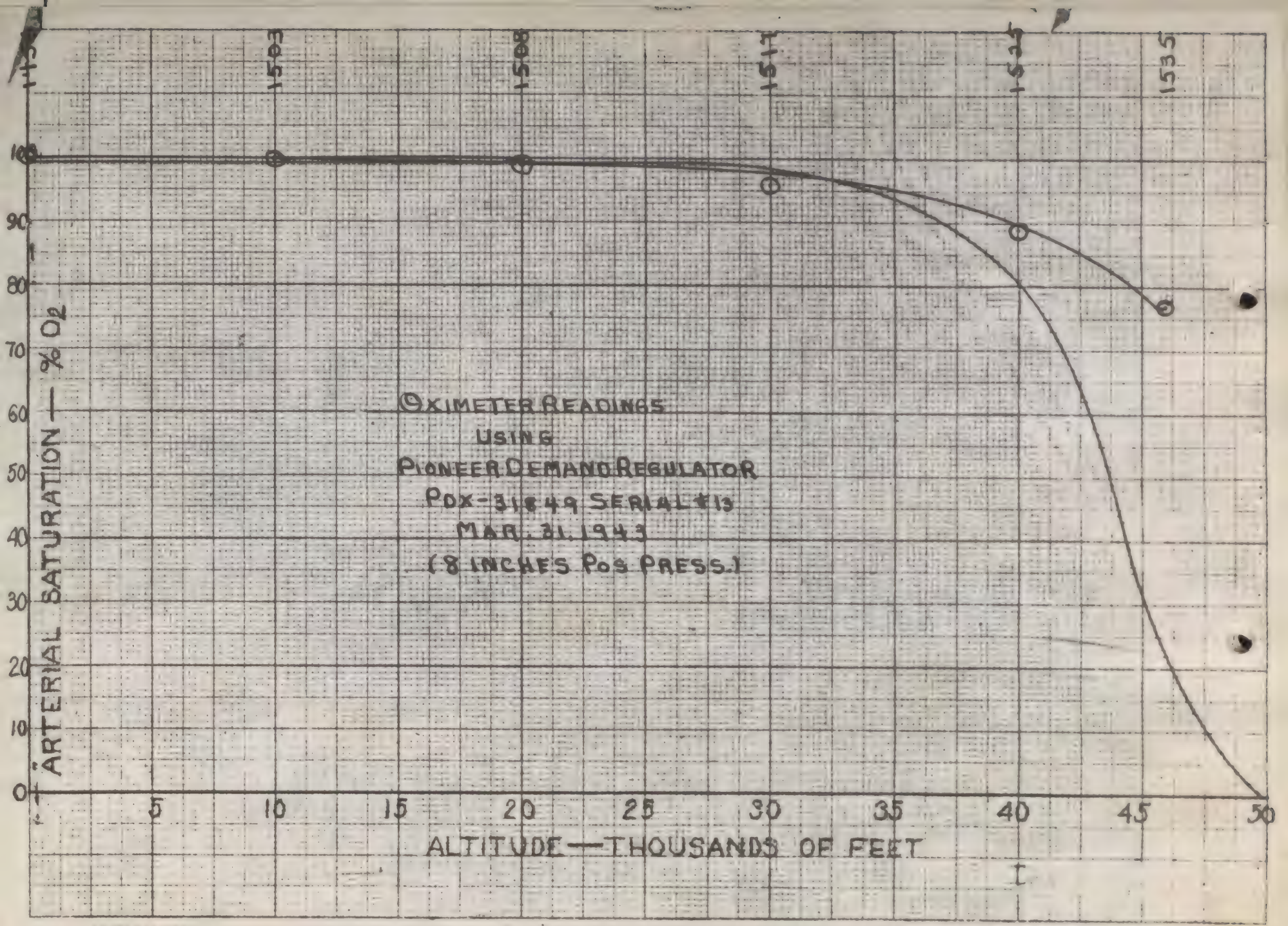
ALTITUDE — THOUSANDS OF FEET
EUGENE DIETZGEN CO NO 346


1503
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ARTERIAL SATURATION — % O_2
OXIMETER READINGS
USING
PIONEER DEMAND REGULATOR
POX-31649 SERIAL #13
MAR. 31. 1943
(8 INCHES POS PRESS.)
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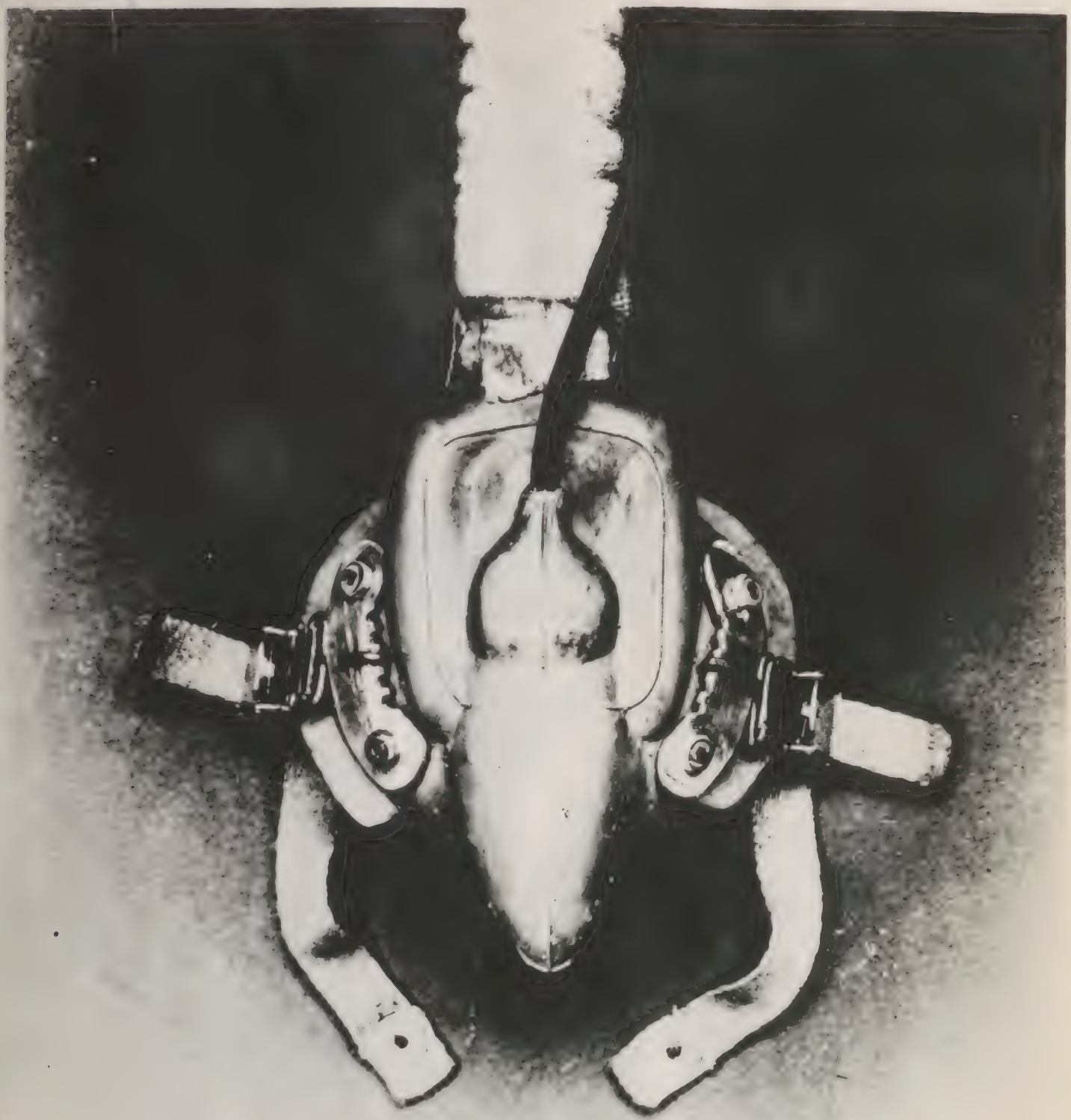
ALTITUDE — THOUSANDS OF FEET

PHILADELPHIA

OFFICIAL PHOTOGRAPH
NOT FOR PUBLICATION

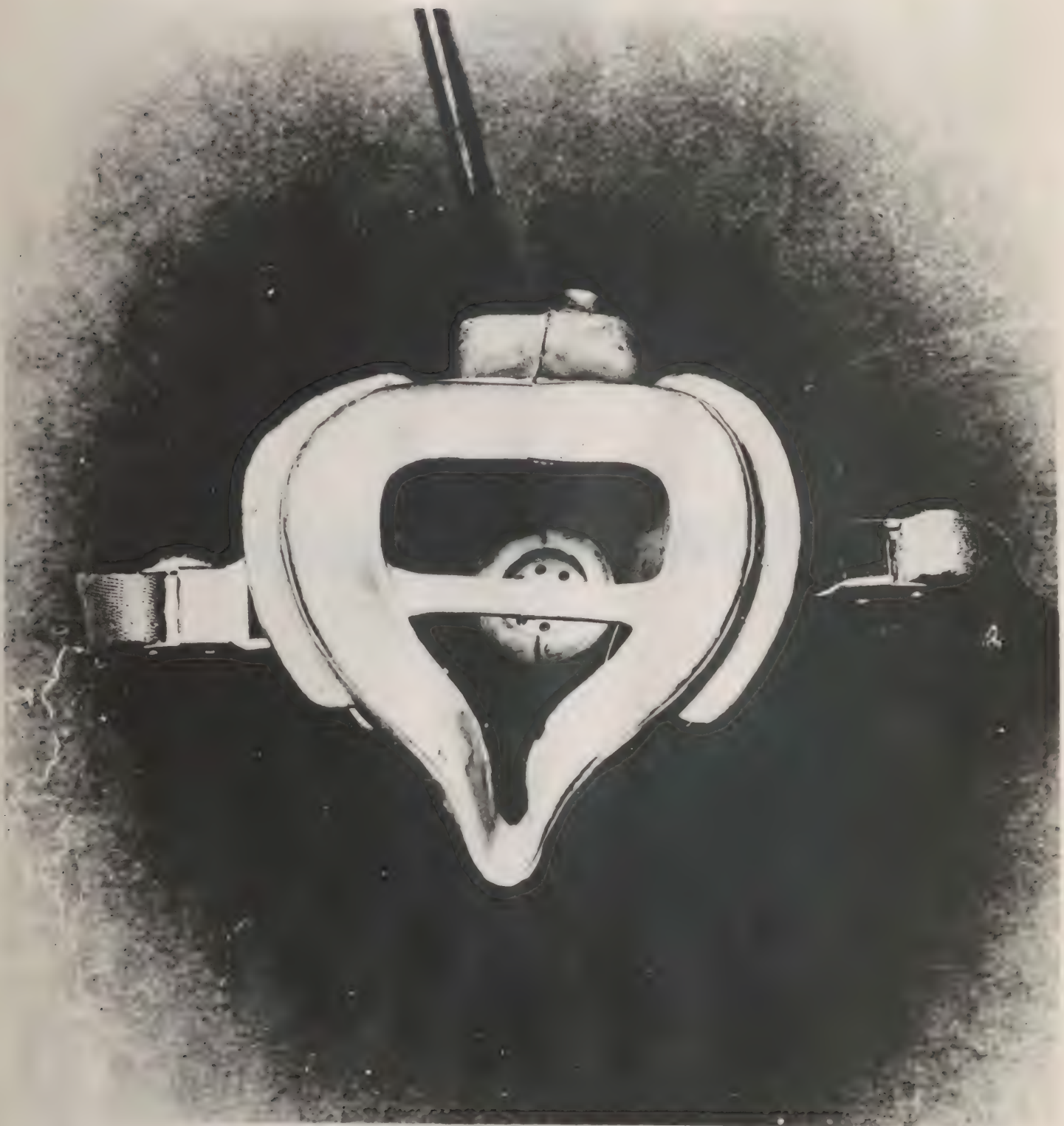
NEGATIVE NUMBER 228607



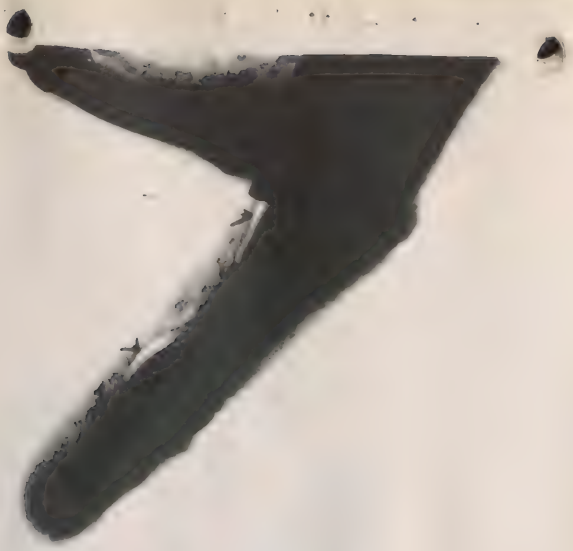
N.A.F. MODIFICATION OF ARMY M.S.A. MASK

NAVAL AIRCRAFT FACTORY
NAVY YARD, PHILADELPHIA

NOT FOR PUBLICATION



N.A.F. MODIFICATION OF ARMY M.3.A. MASK



1

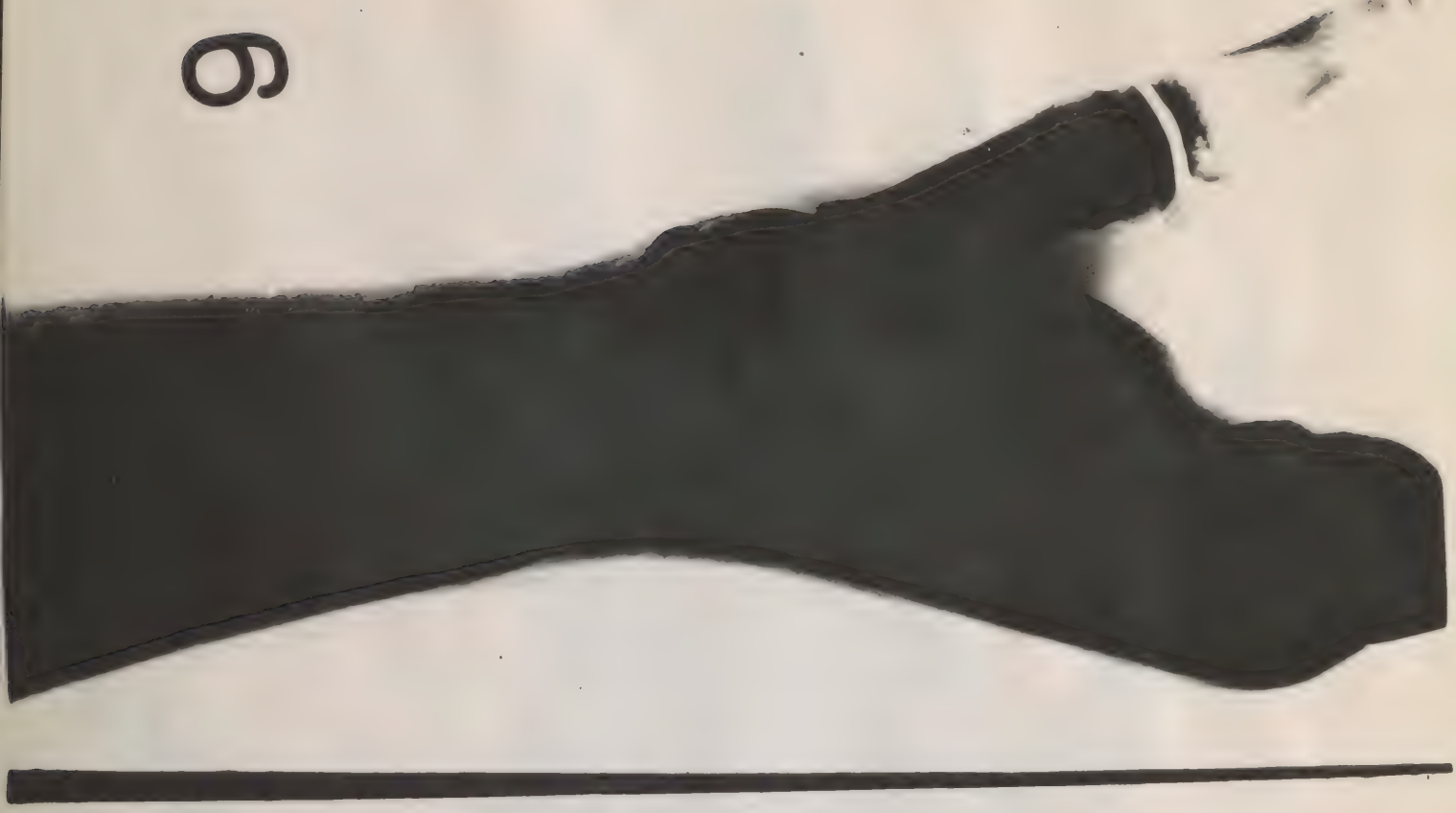
GAS BUBBLES IN TENDON SHEATHS OF FINGER - 46,000 FEET

4

GAS BUBBLES IN TENDON SHEATHS OF FINGERS - 46,000 FEET

GAS BUBBLES IN WRIST JOINT - 46,000 FEET

6



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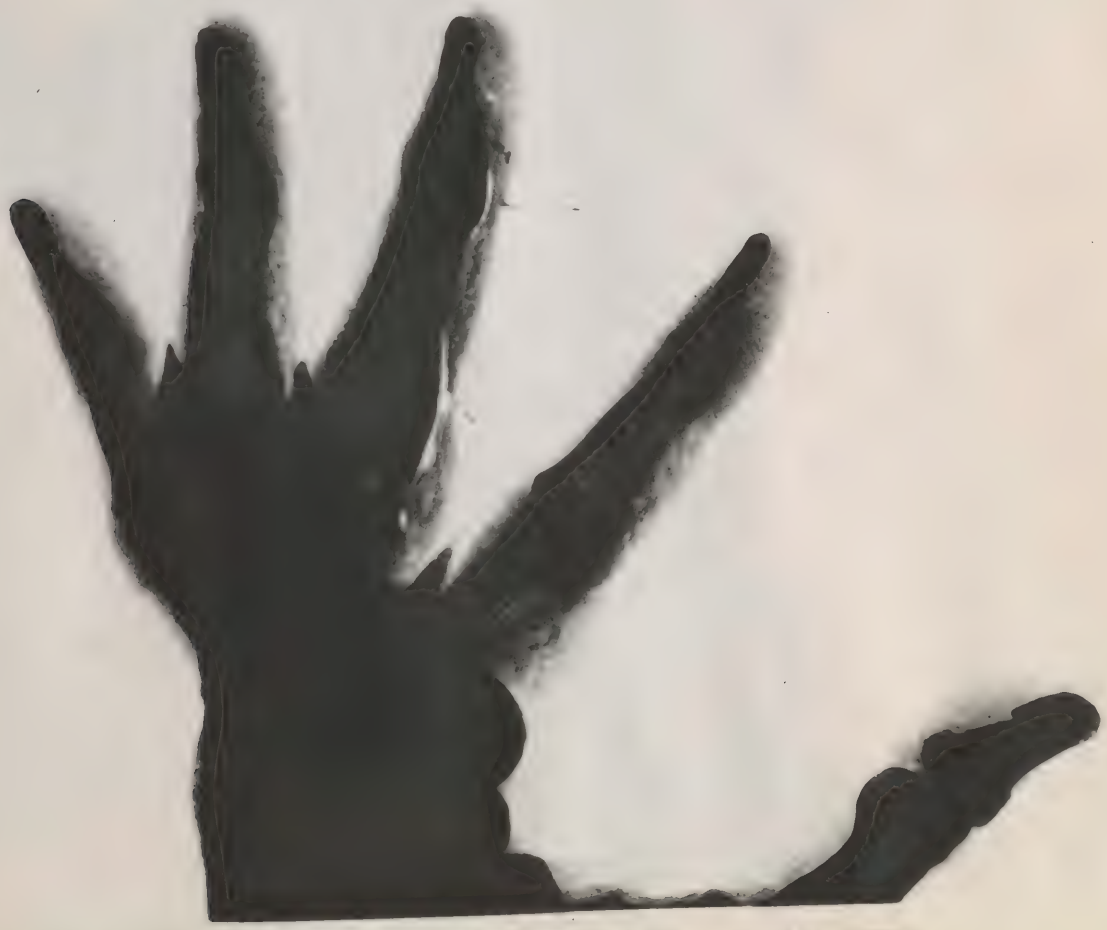

GAS BUBBLES IN TENDON SHEATHS OF FINGER - 46,000 FEET

2

GAS BUBBLES IN WRIST JOINT - 46,000 FEET

LOW PRESSURE-TEMPERATURE CHAMBER
NAVAL AIRCRAFT FACTORY
PHILADELPHIA. PA

DATE 3-22-43

Name Dr D Gressly Dept. A.M.S

Age 33 Temp. _____ Resp. _____ Pulse _____ B.P. _____

Weight 190 Height _____

Denitrogenation? none Duration — Exercise--Type — Speed —

Barometer 30.07" Room Temperature 64° F

Time or Take-off 1432 Time Return to Ground 1546

Mask? M.S.A Type Pos. press (type-d) Regulator, type Pioneer neg. demand

Clothing: regular

Mission: 8 K ft. dive - oximeter tested - Pioneer reg. used

TIME	ALT.	R. TEMP.	(a)-(b) OXIM.	SYMPTOMS, REMARKS - ALVEOLAR SAMPLE
1432	0'	8"	100-100	a-right ear (b-left ear = thin)
1435	10,000'	"	100-100	
1439	20,000'	"	97-98	
1446	30,000'	"	93-94	
1448	35,000'	"	89-92	bothers minimum.
1455	"	"	89-93	
1458	37,000'	"	87-89	
1503	"	"	87-89	
1505	40,000'	"	83-86	
1510	"	"	82-86	cough & expiration at middle fingers
1511	42,000'	"	79-83	
1516	"	"	78-81	
1518	44,000'	"	74-77	
1523	"	"	73-76	
1528	46,000'	"	69-73	gas cond good
1533	"	"	69-71	descent
1544	0	"	92-93	ground 12 oz - reached - OK.

(over)

Return to Ground _____ Temp. _____ Pulse _____ Resp. _____

B. P._____

CONCLUSIONS AND SUMMARY

(Not to be completed until interrogation of individual 24 hours later)

Operator

Observer

Signed

Flight Surgeon

LOW PRESSURE-TEMPERATURE CHAMBER
NAVAL AIRCRAFT FACTORY
PHILADELPHIA, PA

DATE 3-24-43

Name Dr D. Grissly Dept. AMS

Age 33 Temp. _____ Resp. _____ Pulse _____ B.P. _____

Weight 190 Height _____

Denitrogenation? none Duration — Exercise--Type — Speed —

Barometer 30.17 Room Temperature 64°F

Time or Take-off 1414 Time Return to Ground 1533

Mask? M.S.A Type new (type-d) Regulator, type Pos press #13 Pioneer Reg demand

Clothing: regular

Mission: testing oximeter & Pioneer reg on mask

TIME	ALT.	TEMP.	OXIM.	SYMPTOMS. REMARKS - ALVEOLAR SAMPLE
1414	0	8"	100-100	(a-1st sac) (b-2nd sac)
1416	10,000	"		thin milk
1417	"	"	100-99	
1421	20,000	"		
1422	"	"	95-97	
1425	30,000	"		
1426	"	"	93-94	
1428.5	35,000	"		
1430	"	"	88-90	
1433	"	"	88-90	
1434	38,000	"		
1435	"	"	87-88	mild pain left thigh
1438	"	"	85-87	
1440	40,000	"		
1441	"	"	81-84	(a-sac used)
1444	"	"	85-84	itching of nose — no pain
1446	42,000	"		
1447	"	"	80-79	
1450	"	"	80-78	Pain much good
1452	44,000	"		
1453	"	"	74-73	
1455	"	"	74-74	
1458	46,000	"		
1459	"	"	69-65	
1502	"	"	67-70	(b-sac thick) crepitus at hand
1505	"	"	66-69	Slight pain at clavicle - pain hand good.
1510	"	"	64-68	Considerable abdominal distention pain
1512	"	"	66-68	

(over)

Return to Ground _____ Temp. _____ Pulse _____ Resp. _____

B. P._____

CONCLUSIONS AND SUMMARY

(Not to be completed until interrogation of individual 24 hours later)

Operator

Observer

Signed

Flight Surgeon

LOW PRESSURE-TEMPERATURE CHAMBER
NAVAL AIRCRAFT FACTORY
PHILADELPHIA, PA

DATE 3-24-43

Name Dr. D. Grassly Dept. AM.S

Age 33 Temp. _____ Resp. _____ Pulse _____ B.P. _____

Weight 190 Height _____

Denitrogenation? none Duration — Exercise--Type — Speed —

Barometer 30.17" Room Temperature 64° F

Time or Take-off 1414 Time Return to Ground 1533

Mask? M.S.A Type Pos press (4 p2 - d Regulator; type #13 Pioneer Rzg demand

Clothing: regular

Mission: testing oxi water & Pioneer reg on mask

TIME	ALT.	R. (a) (b)	OXIM.	SYMPTOMS, REMARKS - ALVEOLAR SAMPLE
1520	46,000'	10"	92-90	Pain at shoulder ++ rapid onset
1524	"	"		Arm - upper axillary portion of chest tender on palpation - descent
1533	0'	"		ground level reached - OK
1534	0'	"	89-90	(a - gas thru) (b - gas used)

(over)

Return to Ground _____ Temp. _____ Pulse _____ Resp. _____

B. P. _____

CONCLUSIONS AND SUMMARY

(Not to be completed until interrogation of individual 24 hours later)

Operator

Observer

Signed

Flight Surgeon

LOW PRESSURE-TEMPERATURE CHAMBER
NAVAL AIRCRAFT FACTORY
PHILADELPHIA, PA

DATE 3-31-43

Name Lt. D. Gressly Dept. A.M.S.

Age 33 Temp. _____ Resp. _____ Pulse _____ B.P. _____

Weight 190 Height _____

Denitrogenation? none Duration — Exercise--Type — Speed —

Barometer 29.94" Room Temperature 68° F

Time or Take-off 1456 Time Return to Ground 1547

Mask? MSA Type new (type-d) Pos. Press Regulator, type demand +13 Pioneer reg.

Clothing: regular (Pos press reg on mask)

Mission: Testing oximeter, Pioneer regulator, heart meter

TIME	ALT.	TEMP. R	OXIM.	SYMPTOMS, REMARKS - ALVEOLAR SAMPLE
1456	0'	8"	100-100	Both ears thru
1459	10,000'	"	100-100	
1503	"	"	100-100	
1505	20,000'	"	100-100	
1508	"	"	100-100	
1509	"	"	98-99	
1510	30,000'	"	97-98	
1517	"	"	95-97	
1520	40,000'	"	90-91	Considerable abd. distension
1523	"	"	89-89	
1525	"	"	89-90	Both ears used - no pain
1529	46,000'	"		Considerable abd distension & pain
1532	"	"	75-76	
1535	"	"	78-80	Considerable abd distension pain increasing
1539	"	"		Did not feel well - pain severe - Descent 5,000' min
1547	0	"	99-98	ground level reached - OK

(over)

Return to Ground _____ Temp. _____ Pulse _____ Resp. _____

B. P._____

CONCLUSIONS AND SUMMARY

(Not to be completed until interrogation of individual 24 hours later)

Operator

Observer

Signed

Flight Surgeon